REMARKS

Claims 1-16 were pending and examined. Claims 1-16 have been rejected by the Examiner under 35 U.S.C. §103. No claims are objected to and no claims are allowed.

By this Amendment and Reply, Claims 1, 2, 8, 9 and 11-16 are amended, no claims are cancelled and Claims 17-22 are added. Accordingly, Claims 1-22 are presented for further examination. Favorable reconsideration of this application in light of the following discussion is respectfully requested.

Prior Art Rejections:

In the Office Action the Examiner rejects Claims 1-16 under 35 U.S.C. §103(a) as allegedly being unpatentable over Chu (U.S. Patent Publication No. 2003/0065663A1) in view of Kemp (U.S. Patent Publication No. 2004/0024775A1). These rejections are respectfully disagreed with, and are traversed below.

Chu is merely seen to disclose a computer-implemented data interface to a knowledge repository and, in particular, an interface (client application 40) for an end user 32 to formulate a request (via a query XML module 42) to retrieve a model stored in one of the knowledge repositories (remotely located repositories 34 and 36). See Chu at paragraphs [0014]-[0016].

As such, Chu is merely seen to disclose a conventional search engine-type query interface for remotely located data stores and, more particularly, an interface for a repository including a model repository 300 and a data mining application 318 for searching volumes of data stored therein.

As the Examiner states in a first full paragraph at page 3 of the Office Action, Chu fails to teach a first level of logical partitions that segregates KID storage into specific personal and professional levels. The Examiner turns to Kemp and proposes combination of the teachings of Chu and Kemp to cure this deficiency.

Kemp is merely seen to disclose a system for fulfilling request from users wanting current information related to legal or other topics designated by users from lists of available topics. See Kemp at the Abstract. At paragraphs [0039]-[0042], Kemp discloses providing current awareness information from one or more information sources 170 by a provider system

101 to one or more requesting users 150. Information is assigned an identification code, label or tag (by manual or automated means) classifying the information by type or class within a topic. Kemp further discloses specific topics and sub-topics within a particular business field, namely, the legal field.

As such, Kemp is merely seen to disclose one of a number of conventional information management systems discussed in the Background Section of the instant application with reference to FIGS. 1 and 2, where data or information is stored in, what the instant application deems, counter intuitive, industry specific data structures. For example, and as noted in the instant application, systems that merely classify data and information in one of a number of broadly defined, analytical topics of importance only within a particular industry (e.g., "securities law", "contract law", "real estate law", and the like, within the legal profession), are not effective systems for storing information as such systems ultimately require detailed methods of locating and retrieving such information (e.g., requiring query functions), and contribute to what the present application describes as "information overload." That is, merely separating data and information purely by broad analytical topics having relevancy only within a subject industry (e.g., the aforementioned legal subject matter categories) still yields, over time, a large collection of data and information related only in that the data and information may reference one of the broad subject matter categories.

Therefore, even if the teachings of Chu and Kemp are somehow combined as the Examiner suggest, a point that Applicant does not admit is suggested, the proposed combination would still not describe or suggest the subject matter of the present invention as is recited in the claims as filed, and as now written. For example, the proposed combination of Chu and Kemp is merely seen to disclose a conventional search engine-type query interface for remotely located data stores including a repository and a data mining application for searching volumes of data stored therein (Chu), and wherein data and information in the repository is stored within one of a number of broadly defined, analytical topics of import to a specific industry, and wherein when stored, the data and information may be assigned an identification code, label or tag (by manual or automated means) classifying the information by a type or class within one of the analytical topics (Kemp).

As discussed below with respect to what is known in the art as the "information pyramid," Applicants submit that this categorization of data and information falls short of a "knowledge" repository as claimed, and further that the mere bundling of data and information within analytical topics does nothing to relate a "value" that the data and information has to a user either personally or professionally. As to the aforementioned "information pyramid," Applicants respectfully direct the Examiner's attention to an Exhibit A, appended hereto and incorporated by reference herein, described in further detail below in a Additional Documents Section of this Amendment and Reply, wherein "knowledge management" systems are defined (at page 15, column 1; 3rd paragraph) as recognizing that "what begins as data ... can, with increasing amounts of human context and assimilation, be promoted to the status of information, then knowledge, then ... wisdom." Accordingly, Kemp is not seen to disclose or suggest even a conventional knowledge management system as would be known to those of ordinary skill in the art.

In contradistinction, the present invention teaches and claims a universal knowledge, information and data store and an interface providing a plurality of logical partitions for segregating and storing knowledge, information and data (KJD), and where the logical partitions include at least a first level of the logical partitions for segregating KID storage into personal and professional levels. That is, contrary to the Examiner's statements in the Office Action, neither Kemp alone, nor the proposed combination of Chu and Kemp, disclose or suggest a first segmenting of KID between personal and professional categories. Moreover, neither Chu nor Kemp are seen to disclose or suggest partitions of KID that are universal and thus, not arbitrary or relevant to only one industry. Rather, as is recited in the instant claims, the logical partitions of the present invention have application across all industry.

Accordingly, it is respectfully submitted that even if the teachings of Chu and Kemp were combined (which is not admitted is suggest), the resulting combination would still not teach or suggest the present invention as is claimed in at least, for example, independent Claims 1 and 16.

Additionally, and merely to streamline prosecution of the present application, clarifying amendments have been made to independent Claims 1 and 16 to even further recite the subject

matter for which Applicants regard as the invention. By example, and referring to Claim 1 as now written, it is said that:

> "said interface providing a plurality of logical partitions for segregating and storing said KID in a priority-based and standardized scheme within said UKIDS, wherein said priority based scheme reflects personal and professional core values of a free enterprise economic system, and wherein said standardized scheme includes a clustering of KID to promote transferability between said receivers, extensibility across data store platforms and scalability in understanding of said KID by each of said receivers, said interface further providing rules and tools for configuring said UKIDS and for storing and accessing KID included therein;" (emphasis added)

Claim 1 is also amended to recite:

> "wherein said rules define methods for allocating KID within one of said plurality of logical partitions, for purging KID from said UKIDS, and for efficiently sharing and distributing KID between said receivers;
>
> wherein said tools include features and functions for presenting news and advertising of interest to said receivers, for identifying targeted storage locations within specific ones of said plurality of logical partitions, for backup and archiving KID and for securing KID in said UKIDS;" (emphasis added)

Independent Claim 16 is amended to recite similar limitations. Support for these amendments may be found in the original disclosure and at least in the application as published at paragraphs [0041] and [0042], and [0045]-[0048]. Thus, no new matter was added.

Referring again to the "information pyramid," Applicants respectfully submit that a true knowledge repository does more than merely tag or label data and information in accordance with subject matter categories of relevance to only one industry as is disclosed by Kemp. Rather, a true knowledge repository includes the recited interface for segmenting and storing KID in, for example, a priority based and standardized scheme, and which includes the recited rules and tools for configuring the knowledge store and for storing and accessing KID stored therein, as is now presented in independent Claims 1 and 16.

In view of the foregoing, it is respectfully submitted that Chu and Kemp, either alone or in the Examiner's proposed combination, are not seen to either expressly teach or suggest the subject matter of the independent claims as now presented. In that the independent claims are patentable over the prior art of record, the dependent claims must also be found patentable.

Accordingly, the Examiner is respectfully requested to reconsider and to withdraw the rejection of Claims 1-16, as now written, under 35 U.S.C. §103(a) as allegedly being unpatentable over Chu in view of Kemp.

Applicants also note that clarifying amendments have been made to Claims 2, 9, and 11-15, to remove reference numerals and to conform the claims to limitations now recited in independent Claim 1. Additionally, Claim 8 was amended to further recite subject matter for which Applicants regards as the invention. Support for the amendment to Claim 8 may be found in the original disclosure and at least at paragraph [0043] of the application as published. Thus, no new matter was added.

Newly Added Claims:

As part of this Amendment and Reply, Claims 17-22 are added. Support for these newly added claims may be found in the original disclosure and in the application as published, at least at paragraph [0052] with respect to Claim 17; at paragraphs [0070]-[0118] with respect to Claims 18-21; and paragraphs [0041], [0042] and [0045]-[0048] with respect to Claim 22. Thus, no new matter is presented.

It is respectfully submitted that Claims 17-22 are also considered patentable over the prior art of record at least for the reasons argued above.

Additional Documents:

Appended to this Amendment and Reply and made a part hereof, is an Exhibit A, which includes a document entitled "The Information Work Productivity Primer", dated 2003. Applicants submit this document to clarify and direct the Examiner's attention to well known terms of the art, such as a term "information pyramid."

Applicants further direct the Examiner's attention to recommends regarding strategies for "personal knowledge management" (PKM) included at page 16, column 2, under the heading "PKM Tools and Technologies" where industry experts note that the conventional teachings is to encourage so called "personally defined and individual" storage of knowledge. It is respectfully submitted that such thinking "teaches away" from the present invention and, in particular, the invention as is recited in the instant claims where a universal knowledge, information and data

store is recited, including an interface for segmenting and storing KID in, for example, a priority based and standardized scheme, and which includes the rules and tools for configuring the knowledge store and for storing and accessing KID stored therein.

Applicants believe that the foregoing amendments and remarks are fully responsive to the Office Action and the claims are allowable over the references applied by the Examiner. Applicants respectfully request that the Examiner reconsider the present application, remove the outstanding rejections, and allow the application to issue.

Applicants have made a diligent and sincere effort to place this application in condition for immediate allowance and notice to this effect is earnestly solicited. To expedite prosecution of this application to allowance, the Examiner is invited to call the undersigned attorney to discuss any issues relating to this application.

No fee is believed due with the filing of this Amendment and Reply, other than a fee for a two-month extension of time described above and for claims in excess of twenty. However, if an additional fee is due, Applicants authorize the payment of any additional charges that may be necessary to maintain the pendency of the present application to the undersigned attorney's Deposit Account No. 50-3342.

Respectfully submitted,
Michaud-Duffy Group, LLP

DATE: February 13, 2008

Michael K. Kinney, Reg. No. 42,740
Attorney for Applicants
Email: kinney@michaud-duffy.com

Michaud-Duffy Group LLP
CenterPoint
306 Industrial Park Road
Suite 206
Middletown, CT 06457-1532
Tel. No.: (860) 632-7200
Fax No.: (860) 632-8269

Information Work Productivity Council

The Information Work Productivity Primer

2003 Research Compendium

EXHIBIT A
of
Amendment & Reply to Office Action
Ser. No. 10/541,798

Information Work
Productivity Council

Contents

Productivity Primer Introduction

Can productivity be measured in a world where competitive advantage comes from new ideas and innovation, where virtual teams and global collaboration have replaced the factory floor or where personal knowledge management accommodates an individual's technology preference for peer-to-peer networks, e-mail or blogging?

To answer these questions executives analyze the business productivity impact of their IT investments while economists strive to measure technology's productivity impact on the economy and its effect on per capita income and living standards. Yet traditional methods of measuring "productivity," real output per hour worked, have become increasingly difficult in the so-called information age.

Academic and industry studies suggest a systematic relationship linking IT to productivity and profitability; however, a standard measurement or methodology that firmly links productivity to IT has not yet been established. The Information Work Productivity Council's 2003 Productivity Primer provides a contextual reference for this nascent effort to measure productivity in a world of ever expanding networks and constantly changing information technologies.

In 1959, when Peter Drucker looked at the emerging information age and coined the term *knowledge worker,* he saw the revolutionary transition from an industrial society to an office-based society. Today, more prosaic jobs of all types—from call center representatives to truck drivers to factory workers—depend on information and technology, thereby enabling productivity, profitability and competitive advantage. Knowledge work has given way to the more inclusive term *information work*, the act of creating, using or sharing information as part of a business process.

Understanding information work is important to building a productivity measurement framework because industries continue to only use standard business measures—physical product (production) and time spent (labor)—as the basis of positive business value.

Professors Baruch Lev of New York University and Suresh Radhakrishnan of the University of Texas reason that if standard business measures tell us little about the origins of superior performance, we must be measuring the wrong things. To identify and measure sources of productivity improvement—particularly in an economy where knowledge, work and information technologies play an increasing role—managers must look beyond the differences that appear on traditional balance sheets. These differences include new ways of thinking about business capital, organizations, structures, labor and accounting methodologies.

MIT Professor Erik Brynjolfsson explains that building a productivity measurement framework first requires an understanding of the information work centric organization and its relation to an "IT Innovation Cluster," a mix of IT embedded in a "cluster" of connected innovations, notably organizational changes and product innovation.

Harvard Business School Professor Marco lansiti and Roy Levien of National Economic Research Associates (NERA) say that our understanding of business performance and productivity may be characterized as a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival.

Analyzing the flow and patterns of information and information work between these interconnected participants, however, has been largely invisible within organizations. Research from Accenture and the International Institute for Management Development in Lausanne, Switzerland, tells us that managers can isolate and calculate their IT expenditures, but have difficulty grasping or measuring the qualitative human aspects of information flow and information work.

Competitive advantage comes not only from IT but the way IT enables information work and information workers. One may reason that if the quality of a network can be measured by the strength of each of its nodes, then the quality of an information-based organization can be measured by the strength of each of its workers.

With the global connectivity and speed of information transmission that technology has introduced into business, the information age represents more of a challenge than anyone would have imagined. The life blood of the new economy is the use, creation, management and delivery of information to create value added products and services. Thus, an understanding of productivity measurement will help businesses and individuals both prepare for and capitalize on the future.

The Information Work Productivity Council (IWPC) is an independent group of companies and academics that have joined together to study the issue of information work productivity and profitability. The goal of the IWPC is to build a model that measures productivity in the information centric business environment of the 21st century. IWPC sponsors include Accenture, Hewlett-Packard, Cisco Systems, Intel, Microsoft, SAP and Xerox.

Information Wealth: From Knowledge Work to Information Work

The world produces between one and two exabytes of unique information per year according to the UC Berkeley study "How much information?" This translates into roughly 250 megabytes for every man, woman, and child on earth.

Technology in the last half century has not only unleashed a vast storehouse of data, but also a geometric explosion of new information and knowledge. Within many organizations, data is now being recorded at unprecedented speed and granularity, often without usable structure or defined goals.

This massive amount of information creates noise and threatens organizational paralysis. The remedy to the problem is informed vision – the ability to innovate and structure information and information processing to facilitate information-based productivity.

Information Work

In 1959, Peter Drucker looked at the emerging work world and coined the term *knowledge worker*. He saw the revolutionary change that was occurring from an industrial society to an office-based society for the people who had to rely on technology to perform their jobs. The technology revolution Drucker witnessed promised to open our vision, unburden our backs, and free our minds for more productive work.

Knowledge work and workers have certainly flourished since Drucker's remarks, and as he noted, we have not yet mastered the issue of knowledge work productivity. The concept of knowledge work, however, is a somewhat elitist term, generally restricted to highly paid scientists and engineers, professionals, and managers. A transformation that is perhaps less noticeable, but just as important, is the intensive use of information in more prosaic jobs of all types—from call center representatives to truck drivers to factory workers.

Knowledge work has become a subset of a much broader occupational category we will call *information work*. Information work is the act of creating, using or sharing information as a part of a business process. In sophisticated economies, the great majority of workers constantly use data, information, and knowledge—each area to varying degrees—in their jobs. They create, manage, share, receive and/or manipulate information.

The U.S. Bureau of Labor Statistics estimates that nearly 70 percent of the 136 million employees in the U.S. non-farm workforce were engaged in some form of information work at the turn of the 21st century.

Despite the massive infusion of information technology into the information workplace, a flowering of productivity never fully materialized for the majority of the workforce; or if that transformation did occur, we cannot measure or document the change. As MIT economist, Robert Solow noted, "We see computers everywhere but in the productivity statistics." Productivity is a well-established concept in economic policy, but it is most easily applied to industrial work.

Tangible assets, such as physical capital and labor measured by product output, still rule the economy. We continue to count physical product (production) and time spent (labor) as the basis of positive business value. Additionally, while information technologies seem to be self-evidently useful in information work, their productivity and quality impacts are far from clear.

Call center workers can answer more customer calls with highly scripted workflow systems, but are their customers more satisfied? Managers can certainly know more about the activities of truck drivers or traveling salespeople with geographic positioning systems and customer relationship management systems, but have these workers been made more productive? Professionals can clearly create more documents with their PCs, word processors, and presentation tools, but how does this change in production help their companies and economies?

Information by itself provides little advantage. It has been twenty years since *Megatrends* author, John Naisbitt, warned, "We are drowning in information but starved for knowledge." As information becomes the foundation of economic wealth, the phenomenon Naisbitt noted will continue to swell. To benefit from this value-generating mechanism, businesses must swiftly adopt and apply methods that will put this glut of information to work without adding substantial amounts of human labor.

Companies with structures that target, align, and organize information to describe, direct, and maintain their strategies and information worker processes will succeed in this new environment. It seems every service provider has a solution to this paradigm, but most do not address the fundamental changes needed to truly enhance and mobilize information work for the benefits it can actually provide.

What distinguishes the "Information Age" from previous eras is that the foundation for wealth—information—can be found everywhere yet it is the ability to organize and apply information in a productive and channeled manner that results in profitability and wealth.

Working in the Information World

Value is generated from information by informed action and knowledge-based decisions. Information work can be performed by information workers through direct action on information delivered to them or through the use of that information to make human decisions based on prior expertise and knowledge derived from the information.

Just as information isn't useful unless it's acted upon, knowledge is only valuable when it is used in meaningful, accurate and productive decisions. In order, then, to understand information work, it must be broken down into business processes and activities involving either informed action or knowledge-based decisions.

Although all information work involves informed action or knowledge-based decisions, it's not all of one piece. It is very important in initiatives to improve information worker productivity so as to begin segmenting the information workforce. Research done by the Information Work Productivity Council has broken down information workers into four key types: experts, collaborators, transactors and integrators.

Infomation Worker Types

Experts are those workers who most often perform independently, with little to no supervision, to create and apply high-value forms of information or knowledge to their work. While they may also interact with others in making decisions as Collaborators do, or analyze data as Transactors do, their role is largely that of a subject matter expert or solo professional practitioner. Physicians, lawyers, and consultants are primarily in this category of information worker.

Transactors, such as call center representatives and financial clerks, make some independent decisions, and might build upon existing information to generate new information, but these workers are mostly supported by information or instructions from other people. Transaction information workers may also interpret the information presented to them and process, or channel it into other forms for reuse.

Collaborators, such as a departmental manager or a professional in a large service firm, use information gleaned from experts and analysts, as well as their own expertise, to address their organizations' objectives and direct or coordinate with other individuals or organizations effectively. These information workers depend on their ability to be in constant contact – by such means as phone, e-mail, or other mobile computer devices – with co-workers, clients and suppliers. Collaborators make knowledge-based decisions based on these team-oriented interactions.

Integrators, such as a computer programmers, nurses, or lower-level engineers, use technology and information to know how or when to complete pre-defined tasks with other team members. Their roles are fairly structured and rely on a static but cross-functional and cross-organizational set of procedures. In the past decade or so, technological advances have rapidly spread into the more mobile Integrator roles through such devices as cell phones and on-board computers. Integrators focus primarily on the performance of group work based on information, rather than on the creation or interpretation of information.

As technology continues to infiltrate all many industries and drive the Information Age forward, it will be the Expert, Transactor, Collaborator and Integrator information workers who will transform information into business value.

Impact of the Information Worker

John Naisbitt, in his 1994 book, *Global Paradox*, surveys the world's major economic trends and observes what he calls a "global paradox" at work, that is, as the world becomes vastly more integrated, the small, agile, and informed players will profit the most.

Companies that focus their activities on examining information work and determining how to provide solutions that drive information worker productivity will be in a position to improve their own productivity, foster stronger relationships with their customers and partners, and stay ahead of their competition.

Ultimately, the Information Age will be measured not by the output of technological products, or millions of bits of technical data, but by the improvement of the actions and decisions derived from that data to drive business performance in a more productive manner.

Susan Conway is the IWPC Industry Director. Tom Davenport is the IWPC Academic Director and holds the President's Chair in Management and Information Technology at Babson College.

References

Lyman, Peter, Varian, Hal R. 2000. "How Much Information?" (URL = http://www.sims.berkeley.edu/research/projects/how-much-info/summary.html). UC Berkeley, Berkeley, CA.

Naisbitt, John, 1995. Global Paradox. Avon Books. New York, NY.

Naisbitt, John, 1986. Megatrends. Warner Books. New York, NY.

Cracking the Productivity Paradox

Now that technology is ingrained in business, are workers actually more productive? Most research linking IT to productivity is not based on true metrics, nor does it include a wide range of IT investments. Professor Erik Brynjolfsson of the MIT Sloan School of Management is doing research on the problem, some of which will be used by the newly created Information Work Productivity Council that will measure and offer a framework for IT productivity.

Brynjolfsson's premise is as follows: "Today, the critical question facing IT managers is not "Does IT pay off?" but "How can we best use computers?"

The greatest benefits of computers appear to be realized when computer investment is coupled with other complementary investments, such as new strategies, new business processes, and new organizations. These latter all appear to be important in realizing the maximum benefit of IT.

Brynjolfsson believes that the firms that are unusually productive are the ones that have overcome the adjustment costs in product or process innovation to find that IT, work output, and human capital interactions positively can predict firm productivity.

In order to understand how companies achieve productivity gains, management must first understand the nature of the information work centric organization and its relation to the "IT Innovation Cluster," a mix of IT embedded in a "cluster" of connected innovations, notably organizational changes and product innovation.

Companies do not simply plug in computers or telecommunications equipment and achieve productivity gains. Instead they must go through a process of organizational redesign and make substantial changes to their service or output mix to achieve the desired success and improvement.

Productivity

An important question that has been debated for almost a decade is whether computers contribute to productivity growth because in the long run productivity determines our living standards and the wealth of nations.

Productivity is a simple concept. It is the amount of output produced per unit of input. While the concept is easy to define, it is notoriously difficult to measure, especially in the modern economy. In particular, there are two aspects of productivity that have increasingly defied precise measurement—output and input.

Properly measured, output should include not just the number of widgets coming out of a factory or the lines of code produced by a programming team, but rather the value of that effort.

Similarly, a proper measure of inputs includes not only labor hours, but also the quantity and quality of capital equipment used, materials and other resources consumed, worker training and education, even the amount of "organizational capital" required, such as supplier relationships cultivated and investments in new business processes.

Productivity growth comes from working *smarter*. This kind of effort means adopting new technologies and new techniques for production.

Today, the critical question facing IT managers is not "Does IT pay off?" but "How can we best use computers?" The greatest benefits of computers appear to be realized when computer investment is coupled with complementary investments. New strategies, new business processes, and new organization all appear to be important in realizing the maximum benefit of IT.

The Information Work Centric Organization

Irrespective of the type of worker most affected by computers, information technology changes the way that humans work and productivity is measured, controlled, or reported. The "information work" centric organization can be restructured to allocate routine, well-defined, and easily automated business processes to computers while separating out more complex business processes for human skills.

For instance, centralized databases enable individual workers to have the necessary information to complete an entire process that was historically fragmented. Such a change shifts workers from a role of functional specialist to process generalist.

In manufacturing, the use of flexible machinery and computerized process controls is often coupled with greater worker discretion, which in turn requires data analysis skills, general problem-solving abilities and management skills applied on to an individual task.

Simple decisions, closely related to individual transactions or other operational actions, have been most amenable to computerization. More complex and cognitively demanding work, such as that of managers and professionals, has proven to be remarkably difficult to automate. Computer automation of such work has been correspondingly limited in its scope.

Computer automation of clerical and blue-collar work typically does not substitute for all of a worker's tasks, but instead replaces a subset of ancillary tasks, and in particular, those tasks that do not require exception processing, visual or spatial skills, or non-algorithmic reasoning.

Highly computerized organizational processes are often accompanied by a greater production of data. Raw data is fodder for analytic or abstract decision–making, such as analyzing customer needs to target new product development, heightening the value of skilled workers, managers and professionals (unless, as has rarely occurred so far, the computer system itself can make such analytical decisions). This change in process will directly lead to a greater demand for skilled labor.

However, because the rate of increase in data availability is typically larger than the ability of firms to adapt their labor pool (a situation referred to as *information overload*), firms must also make organizational adaptations to distribute information processing tasks adequately.

The shift to information work centric organizations may also place greater demands on non-cognitive skills. People vary in their taste or distaste for performance- based incentives, which can be supported by computer-based measurement. People vary in their ability to work in teams. In parallel, the change calls for changed human interaction talents in supervisors.

Supervisors, for example, will need more skills in dealing with customers and suppliers, influencing teammates and colleagues, and inspiring and coaching subordinates. More generally, the changes involve providing the "people skills" that computers lack.

The invention of new technologies and their adaptation to new information work-centric organizational structures has required greater levels of cognitive skills and non-cognitive skills, as well as the need for flexibility and autonomy, than has been evident in traditional employee roles where the production process is fixed and includes limited discretion.

Management's Perspective

According to Brynjolfsson's surveys of managers and case-study literature the most important reasons for investing in IT are product quality improvements, most notably customer service, timeliness, and convenience.

Organizational changes set off by IT investment are intended either to reduce costs or to improve product and service capabilities, although the latter is typically more important.

Similarly, a combination of organizational and technological innovation is required to deliver consistently high levels of customer service. This suggests a three-way cluster of complementarities, namely among product quality improvements (broadly understood), re-organization, and IT investment.

Firms that adopt information technology, complementary workplace reorganization, and new products and services tend to use more skilled labor. The effects of IT on labor demand are greater when IT is combined with particular organizational investments, highlighting again the importance of IT-enabled organizational change.

A survey of managers' opinions on the effects of information technology on work demonstrates that the central tendency of opinion among the responding managers is that computer use increases the need for skilled workers; that computers tend to increase workers' autonomy; and that computers increase management's need and capability to monitor workers. Thus, the people who are making the investment decisions in IT, human capital, and work output definitely detect a relationship between information technology, skilled workers, and productivity.

The IT Innovation Cluster

Companies do not simply plug in computers or telecommunications equipment and achieve productivity gains. Instead they must go through a process of organizational redesign and make substantial changes to their service or output mix. IT is embedded in a "cluster" of related innovations, notably organizational changes and product innovation, which taken together requires a higher-skilled labor mix.

This cluster is critical, since IT use is more likely to be effective in organizations with a higher quality of service output mix, decentralized decision-making, and a higher number of skilled workers. Furthermore, those firms that successfully combine these elements can be predicted to produce more valuable output than their competitors, thus achieving high levels of productivity.

While technologies such as the Internet that lead to improvements in IT are quickly available throughout the economy, complementary organizational changes involve a more difficult process of co-invention by individual firms. Identifying and implementing organizational co-inventions is complicated, costly, and uncertain, yielding both successes and failures. These adjustment difficulties and the experimentation and co-invention surrounding IT use lead to a broad variation across firms in the use of IT, its organizational complements, and the resulting outcomes.

Conclusion

In advanced economies, computers are a promising source of productivity growth. Computers may be the modern-day exemplar of technological progress, but the connection between computers and productivity has proven elusive to quantify.

Investment in computers may make little direct contribution to the overall performance of a firm or the economy until and unless they are combined with complementary investment in work practices, human capital, and firm restructuring.

Brynjolfsson's research finds evidence of a substantial relationship between computers and productivity growth. The results indicate that short-run contribution of computers to output is approximately equal to the direct user cost of computer capital.

However, in the long term, he finds that the implied marginal product and growth contribution of computers rises by an economically and statistically significant margin. The interpretation remains that the long-run contributions rise because computers do complement productivity-enhancing organizational changes carried out over a period of several years.

Brynjolfsson believes that firms that are unusually productive are the ones that have overcome the adjustment costs in product or process innovation, and understand that IT, work output, and human capital interactions do positively predict firm productivity.

New business strategies and processes, as well as new information work- centric organizations, are becoming increasingly important to firms desiring the maximum benefit out of IT investments and increased productivity. Yet, analyzing the effect of computers on productivity is important, not just because the analysis answers the question, "Does IT pay off?" but because productivity growth is key to determining future living standards and the wealth of all nations. ■

References

Brynjolfsson, E. and Hitt, L., 1995. Information Technology as a Factor of Production: The Role of Differences Among Firms. Economics of Innovation and New Technology, 3(3-4), 183-201.

Brynjolfsson, E. and Hitt, L., 1996. Paradox lost? Firm-level evidence on the returns to information systems spending. Management Science, 42(4), 541-558.

Brynjolfsson, E. and Hitt, L. M., 1998. Beyond the productivity paradox. Communications of the Acm, 41(8), 49-55.

Brynjolfsson, E. and Hitt, L. M., 2000. Beyond computation: Information technology, organizational transformation and business performance. Journal of Economic Perspectives, 14(4), 23-48.

Brynjolfsson, E., Hitt, L. M. and Yang, S. K., 2002. Intangible assets: Computers and organizational capital. Brookings Papers on Economic Activity(1), 137-198.

Beyond the Balance Sheet: Measuring Organization Capital

Why do some companies consistently outperform others? This simple question is particularly puzzling in today's highly competitive business environment, where many of the factors of production have become commodities. If Wal-Mart's competitors can access the same pool of labor, plant, property, and equipment, how has Wal-Mart managed to achieve spectacular sales growth year after year?

Professors Baruch Lev of the New York University Stern School of Management and Suresh Radhakrishnan of the University of Texas try to answer this question by exploring the link between business productivity and organization capital in their work *The Measurement of Firm-Specific Organization Capital* (2003).

Lev and Radakrishnan begin with the premise that if standard business measures tell us little about the origins of superior performance, we must be measuring the wrong things. To identify and measure sources of productivity improvement—particularly in an economy where knowledge, work and information technologies play an increasing role—managers must look beyond the differences that appear on traditional balance sheets.

Their research shows that while traditional accounting information is a fairly good predictor of total output, it is a poor indicator of corporate growth. Moreover, they find that the growth performance that is not explained by traditional measures tends to persist over time, and is correlated with spending on information technology.

According to Lev and Radakrishnan, persistent superior performance can be attributed to organization capital. They also believe that stock prices do not fully reflect a firms' organizational capital—firms that persistently outperform their productivity model tend to experience abnormally high market returns.

Their definition of organization capital includes corporate knowledge, business processes, routines, values, and culture — aspects of business that are widely recognized as important, yet difficult to measure.

Lev and Radakrishnan explore various ways of measuring the "missing inputs" in standard models of productivity. and show a strong link between organization capital and business performance. They also discover a close relationship between their measure of organization capital and business' investment in information technology.

"Organization capital includes corporate knowledge, business processes, routines, values, and culture — aspects of business that are widely recognized as important, yet difficult to measure."

What is Organization Capital?

Organization capital does not appear as a line item on the balance sheet of any Fortune 500 company. Nor is there an organization expense anywhere on the income statement. Yet, most executives will admit that intangibles such as organization, knowledge, and corporate culture play an important role in corporate success. The numbers show that these executives are right—the relationship between accounting measures and long-run performance is very weak. Income statements and balance sheets fail to explain much of the long-run variation in growth or stock prices.

In order to reconcile the difference between measured inputs and observed outcomes, researchers have turned to the idea of organization capital. Some proponents of organizational capital conceive of it as an asset that is embedded in the firm's employees and their inter-relationships.

This point of view was stated succinctly by Jim Goodnight, CEO of SAS Institute, with his now famous observation that, "our most valuable assets walk out the door each night." Other scholars view organization capital as a resource that is embedded within the processes, routines, values, and cultures of an enterprise. Both sides view organizational capital as a critical input to the ideas production function—the process of identifying promising new business methods and designs.

Unfortunately, organization capital is idiosyncratic and often very difficult to observe. Different business models, organizations, and routines can be somewhat effective in different competitive environments. Many of the inputs to organization capital, such as a distinctive customer-service culture or high quality mentoring for younger employees, are hard to quantify. Finally, organization capital can gradually become obsolete through imitation, environmental change, or the invention of new and better business models.

In their paper on measuring organizational capital, Baruch Lev and Suresh Radakrishnan address many of these difficult measurement issues by using unexplained firm output as a proxy for organizational capital.

The explained component of firm output is obtained from an economic model, called a production function. The authors use a production function to analyze the relationship between sales and various measurable business inputs for a large sample of companies.

They argue that companies who consistently outperform the model's predicted level of sales must possess a higher quantity of organizational capital than those performing at or below the predicted level. By using persistent differences between actual and predicted productivity as their measure of organizational capital, the researchers can be begin to answer some important questions.

How Important Is Organizational Capital?

The initial findings of Lev and Radhakrishnan are remarkable. They suggest that while organization capital accounts for about three percent of a firm's total output (after controlling other factors such as size and research and development levels), unmeasured organization capital accounts for between 47 and 71 percent of an average firm's growth in sales. These findings suggest that the information in publicly available accounting statements is a poor measure of the factors that lead to sustained productivity growth.

In principle, a firm's stock price reflects more information than appears on its income statement and balance sheet. Therefore, it is natural to ask whether the stock market does a better job of predicting long-run growth than the accounting figures. Lev and Radhakrishnan also consider this possibility. They find that while stock prices do a better job than accounting figures over the long run, the market is still not completely efficient. In particular, the high organization capital firms in their study showed abnormally high stock price returns (approximately 1.5 percent above average) over time frames of less than one year.

Proponents of the organization capital concept argue that it is often a source of competitive advantage because it cannot be easily replicated or transmitted—unlike hard assets, which are increasingly perceived as commodities.

Lev and Radhakrishnan's measure of organization capital proves to be consistent with this intuition. They find that deviations from expected productivity are fairly persistent over time.

Firms that enter the 13-year study with above average performance tend to remain in the high productivity group. Thus, the term "capital" seems to be an appropriate label for the stock of routines, processes, and valuable ideas utilized by these companies.

Finally, Lev and Radhakrishnan examine whether a firm's organization capital is correlated with observable inputs. They find that high-performing firms spend more than average on information technology, as well as selling, general, and administrative expenses (SGA).

These findings are consistent with the work of MIT's Erik Brynjolfsson, who finds that the productivity value of information technology (IT) investments depend largely on a firm's ability to implement a cluster of complementary innovations. These clusters typically include both new technologies and new business methods. Firms with high organization capital are the ones most likely to be making these kinds of productivity-enhancing investments, that appear as IT spending and SGA because they have developed an ability to figure out how new technologies can be applied within their own business context.

Organizational Capital and Information Work

The academic literature on firm productivity provides strong evidence of a link between organization capital and information technology. Several authors have even written about the presence of complementarities—or positive feedback—between IT and organization capital and the individual information worker.

This relationship appears to be exceptionally robust. It has been found in studies of organization capital that focus on firms, as well as studies that focus on the individual information worker. The finding that IT and organizational capital are complements suggests a simple, but important, lesson—computers do not increase productivity on their own. Rather, productivity benefits flow from businesses learning to utilize new technology to solve a particular business problem.

The information worker's job is to transform data into a picture of the business that can be used to guide decisions. In this context, a firm's organizational capital is the set of systems and processes that help an analyst deliver accurate information to decision-makers in a coherent and timely manner. For anyone who has worked in a large organization, it should be clear that these capabilities have as much to do with incentives, rules, culture, and formal structures as with the presence of a particular piece of information technology.

The architects of business organization have a remarkable number of tools at their disposal. These tools include human resource policies, incentive systems, decision rights, formal structures, communication technologies, values, and culture.

However, it remains a tremendous challenge to design a workplace that facilitates intelligent and timely decision-making based on an increasing ability to bring large amounts of relevant data to bear on any particular business problem. Perhaps the most important kind of organizational capital in an increasingly information-centric workplace will be the "meta-capability" of matching new technologies to the kind of workplace configuration that can take advantage of them.

Implications

Lev and Radhakrishnan's research illustrates that the some of the most important aspects of a business do not appear on the income statement or the balance sheet, and are not necessarily reflected in it's stock price. Perhaps, this is not surprising. In an environment where easily measured inputs rapidly become commodities, sustainable competitive advantage must come from a firm's organization capital and other hard-to-measure intangible assets.

Their research implies that there are large benefits waiting for those who develop better direct measures of organizational capital. This is already reflected in finding that stock prices are a stronger predictor of organization capital than accounting data.

Stock prices will generally reflect the decisions of large investors who carefully consider the un-quantified or un-quantifiable aspects of a business before investing. However, the returns to measuring organization capital should be large within firms as well as markets. Peter Drucker is often credited with the maxim: "If you can't measure it, you can't manage it." Lev and Radakrishnan have shown that managing a firm's organization capital is a key factor in achieving superior growth and performance.

Another important implication is that managers should pay attention to the intangible assets that drive long-run performance. Recent history suggests that pressures from stockholders and the media often create large incentives to actively manage the observable dimensions of a business for the short-run. Lev and Radakrishnan show that managing the hard-to-measure issues of organization design remains critical to achieving persistently superior performance over the long term.

Finally, Lev and Radakrishnan's research echoes the work of many authors who suggest a link between organization capital and information technology. In a workplace that is increasingly focused on information work, designing a workplace that allows knowledge workers to effectively tap the data generated by automation of more and more business processes will be an increasingly important organization asset.

References

Brynjolfsson, E., Hitt, L. M. and Yang, S. K., 2002. Intangible assets: Computers and organizational capital. Brookings Papers on Economic Activity(1), 137-198.

Lev, Baruch and Radakrishnan, Suresh, 2003. The Measurement of Firm-Specific Organization Capital. National Bureau of Economic Research, Cambridge, MA.

Business Ecosystems: Productivity's New Order

Many industries today, ranging from energy, transportation and financial services to computer hardware and software behave like a massively interconnected network of organizations, technologies, and consumers, with hundreds of those organizations involved in the design, production, distribution, or implementation of sometimes only a single product.

By comparing networked industrial environments to biological ecosystems in their work *The New Operational Dynamics of Business Ecosystems: Implications for Policy, Operations and Technology Strategy*, Marco Iansiti of Harvard Business School and Roy Levien of the National Economic Research Associates (NERA) explain that our understanding of business health and productivity may be characterized as a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival.

Because of this increasingly distributed industry structure, Iansiti and Levien write that the focus of competition is shifting away from the management of internal resources, and towards the management and influence of assets that are outside the direct ownership and control of the firm.

In networked industrial environments, the performance of any single organization is driven in large part by the characteristics and structure of the entire network, which influences the *combined* behavior of its many partners, competitors and customers. In almost every field, there are advocates of "network approaches" and "swarm intelligence" who insist that breaking up systems, from social networks to industrial organizations, into large numbers of small interconnected components will solve almost any problem and make the system as a whole almost magically better.

But what is the right way to connect components? And are some network structures more productive than others?

Network Hubs and Key Players

Networked structures, ranging from friendships to the links in the World Wide Web, exhibit a characteristic property: a small number of nodes are much more intensely connected than other members of the system. These "hubs," explain Iansiti and Levien, form regardless of the nature of the system, the internal details of the participants within the system, or the specific nature of the connections between members of the system.

Network hubs exhibit an important and unambiguous aspect of network "health": they are robust in the face of random disruptions. Removal of arbitrary nodes from networks with hubs leaves most of the network intact.

The process of technology integration supporting the network and hubs of a business ecosystem therefore provides a critical engine of business evolution, as the products and technological components provided by ecosystem participants are recombined to create product and service offerings.

Three organization types or "firms" perform different roles within this business ecosystem: keystone, dominator, and niche firms.

"Keystone firms" are the regulators of ecosystem health. They are richly connected hubs that provide the foundation for creating niches, regulate connections among ecosystem members, and increase diversity and productivity. They provide a stable and predictable platform on which other ecosystem members can depend, and their removal often leads to the collapse of the entire system. They ensure their own health and survival by directly acting to improve the health of the ecosystem as a whole. The interactions within Wal-Mart's buyer-supplier network as well as Microsoft's developer network (MSDN) represent organizations driven by the collective health and well-being of their respective business ecosystems.

As with keystones, "dominator firms" occupy critical hubs in their ecosystem. However, unlike keystones, dominators progressively take over their ecosystem. The analogy to business ecosystems is clear: these firms eliminate all other firms in their market, often expanding into new markets which they subsequently dominate or even eliminate. Dominators typically damage the health of their ecosystems by reducing diversity, eliminating competition, limiting consumer choices and stifling innovation. Examples of dominator firms include the early days of AT & T to IBM and Digital in the mainframe and minicomputer markets.

A "niche firm" is an organization that exhibits typical (or less than typical) levels of connectivity with other ecosystem participants. Niche players, such as Intuit's Quicken accounting software or AutoDesk's engineering design software, at first glance appear to be the least influential members of an ecosystem; but this is not always the case. In addition to being the most numerous members of the ecosystem, many of them are also located at the "fringes" of the network, where new innovations are actively pursued and where new products and services are developed and new markets explored.

These "edge firms" are critical to the health of the ecosystem because they are the locus of meaningful diversity that we seek to capture with niche creation measures. These firms focus their businesses on areas of narrow expertise by leveraging powerful platforms provided by others.

Ecosystem Health Metrics and Measures

Like any biological ecosystem, a business ecosystem must be capable of facing and surviving perturbations and disruptions. An example of such disruption is discontinuous waves of technological change as inertia hinders the organizational response.

Indicators of business ecosystem health should include a variety of metrics:

Survival rates. Ecosystem participants enjoy high survival rates, either over time, or relative to other, comparable ecosystems.

Persistence of ecosystem structure. Changes in the relationships among ecosystem members are contained; overall the structure of the ecosystem is unaffected by external shocks. Most connections among firms or between technologies remain.

Predictability. Change in ecosystem structure is not only contained, it is predictably localized. The locus of change to ecosystem structure will differ for different shocks, but a predictable "core" will generally remain unaffected.

Limited obsolescence. There is no dramatic abandonment of "obsolete" capacity in response to a perturbation. Most of the installed base or investment in technology or components finds continued use after dramatic changes in the ecosystem's environment.

Continuity of use experience and use cases. The experience of consumers of the ecosystem's products will gradually evolve in response to the introduction of new technologies rather than be radically transformed by them. Existing capabilities and tools will be leveraged to perform new operations enabled by new technologies.

Three key measures for business ecosystem health also must be taken into consideration: robustness, productivity and niche creation.

Because much of the literature on biological ecosystems suggests that networks of many kinds naturally possess "hubs" that enhance certain kinds of network stability, the idea of network stability provides us with robustness, the first generally applicable measure of health.

In a networked structure, the hubs will effectively leverage the network to mount responses to new, uncertain conditions—new product components or new service characteristics can be provided to a customer by leveraging the capabilities of other network participants, as long as enough diversity is present.

As a result, the presence of a stable hub and a diverse community of interconnected entities will be a strong indicator of ecosystem "robustness."

It is not enough, however, that an ecosystem survives and exhibits a stable structure. Ecosystem members must benefit from their connection with the ecosystem. In conservation literature on biological ecosystems, the term "productivity" is a widely used measure of ecosystem health and of its benefits to those who use it: the effectiveness with which the ecosystem converts raw materials into living organisms.

Business ecosystems are constantly subject to new conditions, in the form of new technologies, new processes, and new demands. By analogy then, metrics of productivity should also capture the effectiveness of an ecosystem in converting the raw materials of innovation into lowered costs and new products and functions.

This suggests at least three types of productivity-related metrics:

Total factor productivity. Leveraging techniques used in traditional economic productivity analysis, ecosystems may be compared by the productivity of their participants in converting factors of production into useful work.

Productivity improvement over time. Do the members of the ecosystem and those who use its products show increases in productivity measures over time? Are they able to produce the same products or complete the same tasks at progressively lower cost?

Delivery of innovations. Does the ecosystem effectively deliver new technologies, processes, or ideas to its members? Does it lower the costs of employing these novelties, compared to adopting them directly, and propagate access to them widely throughout the ecosystem in ways that improve the classical productivity of ecosystem members?

Finally, a fairly direct way of observing the third measure, niche creation, will be to determine the extent to which new technologies or "delivery of innovations" are appearing in the form of a variety of new businesses and products.

It is important to note that because it is not just the diversity of any ecosystem that matters, but diversity that creates real value and contributes to ecosystem health. It is therefore essential that new categories of business or niche players be meaningfully new, that they provide new functionality, enable new scenarios, or introduce new technologies or ideas.

Conclusion

In their research, Iansiti and Levien argue that the dynamics of business networks have important operational implications for business practitioners. By recognizing their position within the ecosystem—keystone, dominator, or niche firm—and pursing strategies appropriate to their role, firms can set realistic expectations for themselves and their investors.

The first step in defining a business ecosystem strategy is to analyze the firm's ecosystem and map out the characteristics of its keystone firms, niche firms and dominators. Questions to ask include: Do strong keystones exist? Are there multiple keystones that compete for the same role? How many keystones should the firm tie into? Who are the niche firms? Do any dominators exist?

By understanding how innovations propagate through the network of firms in an ecosystem, firms can better target their relationships. By understanding the dynamics of integration and niche formation, product architects can craft their designs in anticipation of how they will fit into the ecosystem as a whole.

Finally, all ecosystem members can better understand their operational challenges, and respond to and synergize with the collective behavior of their ecosystems. In essence, these implications are important because mastering the complex distributed dynamics of a business ecosystem requires the development of capabilities that are quite different from those that are necessary for competing in a more traditional environment.

References

Iansiti, Marco and Levien, Roy. The new operational dynamics of business ecosystems : implications for policy, operations and technology strategy. [Cambridge, Mass.] : Harvard Business School, Division of Research, c2002. 03-30

Maximizing Business Performance through Information Efficiency

Measuring the business value of information work takes more than investments in enabling technologies. In the 1980's, when Robert Solow coined the term, the "IT productivity paradox," it expressed businesses' frustration with expensive systems and software that could not produce demonstrable or measurable business advantage or bottom-line impact.

The problem lies in the fact that analyzing the flow and patterns of information and information work has been largely invisible. Managers could isolate and calculate their IT expenditures, but they could not grasp or measure the qualitative human aspects of information use and information work.

Managers often overlook the human element with regard to information work: what people do with information and how they take part in its gathering and dissemination is as important as the technology they work with. This fact encompasses the management systems and practices developed by people within the organization and how their behaviors and values shape their actions regarding information.

Until managers can measure information use, it is difficult to measure the return on investment of information work. Technology is essential to the effective use of information but it is people who must develop the systems for collecting, organizing, processing and sharing information. Human performance must be part of the equation if a company is to have mature information capabilities for maximum business performance.

Information Orientation

Researchers at Accenture and the International Institute for Management Development in Lausanne, Switzerland, have explored three interconnected requirements for getting full value from a company's use of information. The research project looked for a causal relationship between good information practices and business performance, which was measured by profitability, reputation, market share and innovation in products and services.

The purpose of the research was to understand how senior managers perceive the relationship between business performance and the three information capabilities – IT, information management, and people's behaviors and values related to the use of information.

As a result, Accenture and IMD developed a new management framework called "Information Orientation." Information Orientation or IO helps managers identify those areas critical to creating effective information use in their companies. The IO framework was validated using statistical research involving 1,009 senior managers from 98 companies representing 25 industries in 22 countries.

The senior managers participated in a randomly selected international study sample. The majority of survey responses (58 percent) came from CEOs, executive and senior vice presidents, and general managers or directors. 58 multi-item variables were used to measure IT practices (13 questions), information management practices (19 questions), and information behaviors and values (23 questions).

The researchers used perceptual indicators to overcome the challenge of determining a uniform measure of business performance, including wide variations in financial reporting requirements and accounting standards of 22 countries, both public and privately held firms, and the need to gather five years of past performance data.

To address the major research question "Does effective information use lead to better business performance?" the study adopted a statistical analysis approach successful in determining whether the presence of first order factors (IT practices, information management practices, information behaviors and values) or a second order factor (IO), best predicts an increase in a business performance criterion.

Statistical evidence showed the causal link from IO to business performance, indicating that IO is a major contributing factor to superior business performance.

Information Capabilities

From these results the researchers also confirmed the existence of the three "information capabilities" associated with effective information use: information behaviors and values; information management practices; and information technology practices.

Ultimately, information capabilities hold the key to strategic advantage, helping a company control costs and grow its business in the new economy. Information capabilities also help companies unleash corporate knowledge for competitive advantage and reveal how information can be properly managed to produce real business value. This helps companies not only invest in appropriate IT systems and infrastructure, but also consistently orient their people to managing and using the information effectively.

The Three Key Information Capabilities

Information behaviors and values. A company's ability to instill and promote positive behaviors and values for effective information use. Practices include information integrity, formality, control, transparency, and sharing. Proper email use is an example of an information behavior and value.

Information management practices. A company's ability to manage information effectively over its life cycle, including sensing, collecting, organizing, processing and maintaining information. Managers who set up business processes, train their employees, and take personal responsibility for information management focus their organizations on the right information. They reduce information overload, improve the information quality available to employees and customers, and enhance their company's decision making ability.

Information technology practices. A company's ability to effectively manage IT applications and infrastructure to support operational decision making and business processes as well as innovation and management decision needs. Managers who link business strategy to IT strategy can most effectively manage necessary IT infrastructure and applications.

Information Capability Competitive Advantage

To gain competitive advantage, companies can employ the IO measure as part of a change project or launch of an IT-driven initiative, such as a new CRM system, to focus management teams on critical success factors that may be intangible or unseen.

For example, before the project begins, an IO assessment can help to build a common language and working culture that values good information management behaviors with customers, partners, and colleagues. The IO measure has also been used by managers to get a stalled or troubled effort back on track by highlighting those issues that are acting as barriers to overall success. Finally, the IO measure has been used as a benchmark following an IT project to prepare for second generation IT efforts.

Accenture's research cites Ritz-Carlton hotels and SkandiaBanken as examples of companies that have developed strong information capabilities and are top competitors in their fields. Ritz-Carlton employees are screened and hired for their service orientation and can-do attitude, then given more than 100 hours of training to make them problem solvers and idea generators.

When a service shortfall occurs, the problem is documented in a "guest instant action report" that captures data on what went wrong for whom and why. Employees can then learn and future problems can be avoided.

SkandiaBanken, a subsidiary of Skandia, one of Sweden's largest insurance companies, has quickly become the first bank in Sweden to successfully challenge the dominance of larger, more established domestic banks. And it was one of the first to market financial products directly by telephone and the Internet. The company's goals were to secure loyal customers by offering convenient, attractively priced financial products and to build a banking model flexible enough to adapt to the rapid, disruptive changes anticipated in the financial services industry.

The bank fostered a culture in which information was readily shared and all employees were encouraged to provide solutions. Among the results: SkandiaBanken was named bank of the year (for overall banking services) by a major Swedish business magazine in 1998 and 1999—the first time this award was given to the same bank two years in a row.

Conclusion

IT practices alone do not result in superior business performance. As the IT productivity paradox has shown, companies that invest in information technology only and treat IT as a cost center rather than as an integral part of the way business is done will be disappointed.

The research does suggest that Information Orientation and the three Information Capabilities of IT practices, management of information and information behaviors must be strong and working together if superior business performance is to be achieved; thus providing a critical link to business performance and can be used as a new management measure.

References

Marchand, Donald A., Kettinger, William J., Rollins, John D. 2001. Making the Invisible Visible: How Companies Win with the Right Information, People and IT. John Wiley & Sons, Inc, Hoboken, NJ.

Marchand, Donald A., Kettinger, William J., Rollins, John D. 2002. Information Orientation: The Link to Business. Oxford Press, New York, NY.

The Knowledge Workbench of the Future

The concept of personal knowledge management has evolved from its predecessor of almost the same name. The term "knowledge management" is widely attributed to renowned management specialist and author Peter Drucker, who coined it during the mid-1980s in the context of an economy shifting from an industrial model to a more knowledge-based one.

The years since have seen many significant technological advances, not the least of which has been global adoption of the World Wide Web as an information-sharing medium. In the modern so-called information age, characterized by an abundant supply of cheaply distributed yet inconsistently substantiated information sources, much has been written about the virtues of knowledge management (KM) principles. With a corporation's competitive edge increasingly determined by its ability to streamline costs and generate innovative new ideas, it has become a business imperative to leverage the organization's collective internal knowledge.

KM recognizes that what begins as data (the most plentiful and least immediately comprehensible resource) can, with increasing amounts of human context and assimilation, be promoted to the status of information, then knowledge, then (rarest and most coveted of all) wisdom. The layers of meaning applied to each level of this "information pyramid" result from distinctly human intervention—individuals making sense of the infoglut to produce valuable intellectual capital.

From this comes the contemporary notion of knowledge workers: professionals now challenged with a work environment that demands increasingly complex information-processing skills and an ever-broadening knowledge domain. KM acknowledges, on the one hand, the increasing value of such skilled individuals to the organizations they serve and, on the other, the high cost of losing them (and therefore their knowledge) at the end of the, or worse, permanently.

A KM initiative typically asks: What technologies would foster an environment that captures, archives, and distributes our collective internal knowledge? Popular KM themes include: quick and easy information access and retrieval, less redundant work (reinventing the wheel), and delivering the right information to the right people at the right time.

Roadblocks to the successful practice of knowledge management do, however, exist. Few incentives or corporate mandates can overcome the fact that individuals have legitimate reasons for not sharing what they know (knowledge equals power). Enterprise-wide KM initiatives have generally required that knowledge workers agree upon and adopt a common set of tools and technologies, that business processes be articulated and mapped to KM objectives, and that there be a unified strategy for categorizing an organization's knowledge assets.

An Alternate Approach

So what is personal knowledge management (PKM), and what does it have to offer that is new?

KM seeks to retain a collective body of organizational knowledge through a process of documentation, codification, archiving, and reuse; PKM seeks to encourage the expansion and development of an individual's own knowledge, using whatever tools and techniques best suit each worker.

Whereas a KM strategy is implemented as a top-down, enterprise wide solution that requires universal consensus and full adoption by all knowledge workers across various disciplines, PKM offers a more flexible, bottom-up approach that responds much more quickly to change and accommodates a spectrum of technology preferences, organization schemes, and personal habits. While KM focuses primarily on benefits to the organization, and secondarily on benefits to individuals, PKM is based on the understanding that the organization will reap rich rewards if the personal success of its individual workers is made a priority.

The essential goals of both are the same: know what you know, pursue expertise, stay current, filter effectively, find meaning, cast a critical and discerning eye, and archive for future use or reflection.

Because an organization that advocates PKM recognizes that effective knowledge workers are just as valuable to its competitors, the organization is more motivated than ever to retain these employees' services. One obvious way to discourage attrition and improve morale is to foster a professional environment in which individuals are empowered to succeed and achieve their highest potential. Such a strategy offers clear benefits to both sides.

To distinguish PKM from KM, it is useful to compare PKM to network theory. If the quality of a network can be measured by the strength of each of its nodes, then the quality of a knowledge-based organization can be measured by the strength of each of its workers. PKM shifts the focus of power from the organization to the individual.

A PKM strategy views the individual knowledge worker as his or her own enterprise, working within a community of others. An essential quality of PKM is the degree to which it embraces the notion of a "knowledge workbench." While traditional KM is most concerned with codifying and preserving the knowledge of humans for archival purposes, PKM appreciates that knowledge is best cultivated through deeper human understanding and ongoing, iterative reflection.

A PKM strategy encourages individual knowledge workers to develop and revisit ideas over time, to articulate key points, and to seek new meaning—either as a personally beneficial exercise or as a social activity with others.

PKM Skills Increasingly Essential in a Knowledge-Based Economy

Research by Steve Whittaker and Julia Hirschberg (2001), cited by Jennifer Hyams and Abigail Sellen of Hewlett-Packard Laboratories (2003), studied the personal document archives of office workers. Typical archives reveal significant percentages of obsolete and low-value information, never-read documents, unique documents (such as notes written by the archive owner), and publicly available materials. Many documents are archived for perceived future value, but inconsistent categorization schemes result in document loss and duplication.

When the metrics of a competitive knowledge-based economy include initiative taking, increased levels of responsibility, innovative thinking, information synthesis, deductive reasoning and assimilation, effective research abilities, and individual contributions, PKM skills offer an important edge

Professors at Millikin University propose PKM for undergraduate students as a means of contextualizing a more integrated learning experience, as an alternative to the traditional narrow focus of a declared major. Millikin is not the only academic institution to advocate PKM principles for its students. The Anderson School at UCLA, for example, has developed a PKM workshop for its MBA students.

Jason Frand, assistant dean and director of computing and information, and Carol Hixon, in a working paper (1999), explain that "PKM, as conceived at the Anderson School, is a conceptual framework to organize and integrate information that we, as individuals, feel is important that it becomes part of our personal knowledge base. It provides a strategy for transforming what might be random pieces of information into something that can be systematically applied and that expands our personal knowledge."

Frand and Hixon's strategy begins by developing a mental map of working knowledge through the creation of an organizational structure. Once that is done, appropriate tools and technologies are selected to extend personal memory, facilitate continuous learning, and support general PKM activities and goals.

PKM Tools and Technologies

Perhaps the most important consideration about tools and technologies used in support of PKM activities is that the best choices are made at the individual level. There is no market for PKM products and services because the best categorization schemes, organization systems, and electronic devices are ones that are very personally defined and best suit an individual knowledge worker's lifestyle and work habits.

PKM is more than simply having immediate and abundant access to information. It is about filtering and qualifying information, finding meaning in it, adding new meaning to it, relating it to personal perspectives, and articulating it for later consumption and development (by the original thinker or others).

PKM does not forget the social ingredients of the tools and technologies. Even a seemingly outdated approach, such as a paper-based filing system, can be as viable as any other solution for an individual knowledge worker for whom developing and maintaining such a system comes most easily and naturally.

In reality, an individual knowledge worker's PKM strategy, reflecting a "knowledge as craft" complexity, will most likely draw from a variety of favorite tools such as personal computers, PDA devices, topical websites or weblogs, notebooks, search engines (personal and external), and so on.

Conclusion

The potential benefits of effective PKM, to be reaped by both individual knowledge worker and knowledge-based organization, include lower attrition rates, higher morale, increased professional confidence, deeper thinking, iterative ideation, lower operational costs, enhanced workplace performance, and greater overall competitiveness. At the individual level, incentives to adopt a PKM strategy are obvious and immediate, set by peer example rather than management-ordered mandate.

References

Association of Knowledgework (retrieved 09/08/2003). Personal Knowledge Management: A Self-Development Guide for Leveraging What You Know (a work in progress: introduction and first two chapters; URL = http://www.kwork.org/).

Avery, S., R. Brooks, J. Brown, P. Dorsey, M. O'Conner (retrieved 09/13/2003). Millikin University, Decatur, IL. (URL = http://www.millikin.edu/pkm/pkm_ascue.html)

Barth, S. (09/2000). Personal Toolkit: Knowledge Tools Need to be Personal, Not Personalized. KM World (URL = http://kmworld.com/publications/magazine/index.cfm?action=readarticle&Article_ID=1338&Publication_ID=76).

Barth, S. (11/27/2000). The Power of One. destinationKM.com (URL = http://www.destinationkm.com/print/default.asp?ArticleID=615).

Davenport, T. (10/01/1998). Let's Get Personal. CIO Magazine (URL= http://www.cio.com/archive/100198_think.html).

Frand, J. and C. Hixon (12/1999). Personal Knowledge Management: Who, What, Why, When, Where, How? Working paper (URL = http://www.anderson.ucla.edu/faculty/jason.frand/researcher/speeches/PKM.htm).

Holbrook, P. (06/07/2002). Blogging as Part of a Personal Knowledge Management Strategy. Personal blog entry (URL = http://weblog.bluepenguin.us/archives/2002/06/07/blogging_as_part_of_a_personal_knowledge_management_strategy.html).

Hyams, J. and A. Sellen (02/06/2003). Gathering and Sharing Web-Based Information: Implications for "ePerson" Concepts. HP Laboratories Bristol.

Jain, R. (07/03/2002). Google + Blog = Personal Knowledge Management System. Personal blog entry (URL = http://www.emergic.org/archives/2002/07/03/).

Information Technology and Productivity: Literature Review

Computers have had a tremendous impact on business productivity since their first commercial use, more than four decades ago. Nevertheless, the questions of how much computers have contributed to economic growth, and whether the latest information technology innovation is productivity enhancing have proven remarkably durable.

Much of existing productivity research has been motivated by Robert Solow's now famous quip, "We see the computer age everywhere except in the productivity statistics." The "productivity paradox"—as Robert Solow's famous observation came to be called—captures the essence of the academic debate over computers and productivity, and provided a convenient starting point for many of the papers written during the 1990's.

Solow's original statement referred to calculations of total factor productivity (TFP) growth based on the sector-level statistics compiled by the federal government. The basic idea behind TFP is that "technological change" (or productivity growth) should be measured as an increase in the total amount of goods and services that can be produced using a fixed level of inputs. While this idea is at the heart of all productivity analyses, the earliest applications utilized macro-economic data to analyze economy-wide growth.

Baily and Gordon (1988) were among the first to explore the relationship between computer use and the long-term slowdown in productivity growth that is found in most macro-economic studies of productivity. They found "enormous productivity gains in the manufacture of computers... but little productivity improvement in their use," to be an important part of the overall explanation.

Several years later, Oliner and Sichel (1994) and Jorgenson and Stiroh (1995) re-examined the aggregate data on computers and productivity. Once again, their general conclusion was that while rapid price declines led many producers to substitute IT for other kinds of inputs—particularly in the rapidly growing service sector—there was little evidence of a change in the rate of TFP growth.

The growth surge that occurred during the 1990's caused some authors, such as Baily and Lawrence (2001), to reconsider the case for a "trend-break" in productivity growth.

Others, such as Gordon (2002), continue to attribute the rapid growth of the last decade to cyclical factors, questioning whether IT or the Internet has had any long-run impact on economic growth.

The macro-economic literature on IT and productivity forces us to confront the question of whether we can establish a causal link between economy-wide or sector-level growth trends and patterns of IT investment. Many remain skeptical.

To quote Tim Bresnahan, "Most empirical work [in modern aggregate growth theory] proceeds by comparing growth across countries or by examining changes across time in the same countries... surely two of the least promising empirical strategies ever used in economics."

The growth-accounting exercise also raises a number of difficult measurement questions, such as how to choose the beginning and end-time of a sample period, whether to adjust for the business cycle, and how to account for the relatively rapid depreciation of computing equipment.

Many productivity improvements are not likely to be measured in the national statistics because product-market competition prevents firms from charging consumers for all of the additional benefits they provide. So, while it is clearly important to adjust the national statistics for changes in product quality, these adjustments are somewhat arbitrary and have been shown to have a major impact on many results.

Moreover, as we have seen, IT is increasingly used to produce new goods and services, or to add "information components" to existing offerings as part of a differentiation strategy.

The methodological and measurement difficulties encountered in the aggregate-growth literature caused many researchers to turn towards micro-economic studies of IT and productivity. Here, there is a growing body of evidence indicating that IT investments do produce relatively large average returns (typically measured as growth in sales).

Papers by Brynjolfsson and Hitt (1995, 1996), Lichtenberg (1995), Kwon and Stoneman (1995), and Dewan and Min (1997) all find evidence of a relationship between IT investment and revenue growth at the firm level. Many of these papers also find that while IT investments produce average returns that can be quite large, there is dramatic variation in the returns to IT investing.

This observation led to a number of studies that combined the search for a link between IT and productivity, with an exploration of whether firm characteristics could explain some of this residual variation in the returns to IT spending.

For example, Brynjolfsson and Hitt (1995) found that unobserved firm-specific factors ("intangibles" such as management quality) accounted for up to half of the productivity effect they had attributed to IT investments in earlier work.

Later studies searched for more direct evidence of complementarities between IT investment and firm-characteristics. Greenan and Guellec (1998), Bresnahan, Brynjolfsson and Hitt (2002), and Caroli and Van Reenan (2002) combine data from various surveys of workplace organization to data on IT investment and firm performance.

Their papers suggest that "organizational change" and IT investment are positively correlated, and that they can have mutually reinforcing positive impact on productivity. These findings are also consistent with the results from a large literature within labor economics that considers the impact of technological change on the demand for higher "skilled" labor in the workplace. And, there is additional evidence on the importance of complementarities from studies that focus on the impact of particular technologies in a relatively narrow production setting.

The large and growing literature on the existence of a firm-level relationship between IT and productivity not only suggests a solution to Solow's "productivity paradox," but also indicates that characteristics of the adopting firms are a critical part of the productivity equation.

Unfortunately, the measures of IT investment and/or business organization used in these studies are usually only a crude approximation to the underlying business reality. The organizational measures are typically a response to survey questions about the use self-directed teams, quality circles, training, or team building—concepts drawn from the literature on industrial relations that can be hard to translate to a particular business setting. These measures are generally interpreted in terms of some vaguely defined notion of decentralization or autonomy.

Measures of IT spending are often not much better. Typically, they aggregate spending on a broad range of IT-related infrastructure (computers, networking equipment, software). However, since IT is a general-purpose technology, measuring the stock of computer equipment usually tells us little about the important qualitative features if the actual application.

Moreover, these measures tend to ignore the substantial costs of training; organizational change and process design that typically accompany (or perhaps anticipate) most computer purchases.

Finally, these cross-industry studies typically use changes in revenue as a proxy for changes in output—their primary measure of productivity. While this approach is consistent with the production function framework, we have illustrated changes in product quality, demand conditions, or market competition may confound the relationship between sales-growth (profits) and productivity.

Conclusion

Two promising directions for future research on the question of IT and productivity. The first approach focuses on analyzing particular technologies within narrowly defined settings. This approach allows an analyst to identify and analyze the productivity effect of a specific technology, used for a particular application within a given organizational setting. Focusing on a particular technology also reduces the significance of measurement problems, particularly when technical or operational performance measures are available.

The second approach analyzes some of the broader impacts of IT on industry structure. While these studies shed some light on the larger picture of IT and industrial change, they move away from the traditional models of productivity and the results can also be hard to generalize.

However, studies suggest that there are important and general lessons to be learned about the relationship between characteristics of a particular IT application and the nature, magnitude, and timing of industry-level that it produces.

After more than a decade of research, scholars have produced a great deal of evidence on the relationship between IT and productivity. While it has proven difficult to locate the evidence that Solow was searching for in the aggregate statistics, there appears to be a systematic relationship between IT and productivity at the firm level.

As we continue along this line of research, new studies will shed additional light on important unanswered questions about the complex relationship between IT, productivity, and firm or industry organization.

2003 Productivity Bibliography

Acemoglu, D., 1998. Why do new technologies complement skills? Directed technical change and wage inequality. Quarterly Journal of Economics, 113(4), 1055-1089.

Appleyard, M. M. and Brown, C., 2001. Employment practices and semiconductor manufacturing performance. Industrial Relations, 40(3), 436-471.

Athey, S. and Stern, S., 2002. The impact of information technology on emergency health care outcomes. Rand Journal of Economics. 33(3), 399-432.

Athey, Susan. Stern, Scott and National Bureau of Economic Research, 1998. An empirical framework for testing theories about complementarity in organizational design. National Bureau of Economic Research, Cambridge, MA.

Autor, D. H., Katz, L. F. and Krueger, A. B., 1998. Computing inequality: Have computers changed the labor market? Quarterly Journal of Economics, 113(4), 1169-1213.

Autor, D. H., Levy, F. and Murnane, R. J., 2002. Upstairs, downstairs: Computers and skills on two floors of a large bank. Industrial & Labor Relations Review, 55(3), 432-447.

Autor, David H., Levy, Frank, Murnane, Richard J. and National Bureau of Economic Research, 2001, The skill content of recent technological change : an empirical exploration. National Bureau of Economic Research, Cambridge, MA.

Baily, M. N. and Lawrence, R. Z., 2001. Do we have a new E-conomy? American Economic Review, 91(2), 308-312.

Baker, George P., Hubbard, Thomas N. and National Bureau of Economic Research, 2000, Contractibility and asset ownership: on-board computers and governance in U.S. trucking. National Bureau of Economic Research, Cambridge, MA.

Baker, George P., Hubbard, Thomas N. and National Bureau of Economic Research, 2002, Make versus buy in trucking : asset ownership, job design and information. National Bureau of Economic Research, Cambridge, MA.

Barclay, M., Hendershott, T. and McCormick, D.T., forthcoming. Competition Among Trading Venues: Information and Trading on Electronic Communications Networks. Journal of Finance.

Bartelsman, Eric, Van Leeuwen, George and Nieuwenhuijsen, Henry, 1998. Adoption of Advanced Manufacturing Technology and Firm Performance in the Netherlands. Economics of Innovation and New Technology. 6(4), 291-313.

Bates, D. W., Leape, L. L., Cullen, D. J., Laird, N., Petersen, L. A. et al., 1998. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. Jama-Journal of the American Medical Association, 280(15), 1311-1316.

Beamish, A., Levy, F., Murnane, R. J. and Autor, D. H., 1999, Computerization and Skills: Examples from a Car Dealership.

Berman, E., Bound, J. and Griliches, Z., 1994. Changes in the Demand for Skilled Labor within United States Manufacturing - Evidence from the Annual Survey of Manufactures. Quarterly Journal of Economics. 109(2), 367-397.

B

Journal of Economics, 113(4), 1245-1279.

Bitler, Marianne P. and Federal Reserve Bank of San Francisco, 2001, Small businesses and computers: adoption and performance. Federal Reserve Bank of San Francisco, San Francisco, Calif.

Black, S. E. and Lynch, L. M., 2001. How to compete: The impact of workplace practices and information technology on productivity. Review of Economics and Statistics, 83(3), 434-445.

Black, Sandra E., Lynch, Lisa M. and National Bureau of Economic Research, 2000, What's driving the new economy : the benefits of workplace innovation. National Bureau of Economic Research, Cambridge, MA.

Bresnahan, T., 1999a, The Changing Structure of Innovation in the Computer Industry. In: David C. Mowery and National Research Council (U.S.). Board on Science Technology and Economic Policy (Eds.), U.S. industry in 2000 : studies in competitive performance. National Academy Press, Washington, D.C.

Bresnahan, T. F., 1986. Measuring the Spillovers from Technical Advance - Mainframe Computers in Financial Services. American Economic Review, 76(4), 742-755.

Bresnahan, T. F., 1999b. Computerisation and wage dispersion: An analytical reinterpretation. Economic Journal. 109(456), F390-F415.

Bresnahan, T. F., Brynjolfsson, E. and Hitt, L. M., 2002. Information technology, workplace organization, and the demand for skilled labor: Firm-level evidence. Quarterly Journal of Economics, 117(1), 339-376.

Bresnahan, T. F. and Greenstein, S., 2001. The economic contribution of information technology: Towards comparative and user studies. Journal of Evolutionary Economics, 11(1), 95-118.

Bresnahan, T. F. and Trajtenberg, M., 1995. General-Purpose Technologies - Engines of Growth. Journal of Econometrics. 65(1), 83-108.

Bresnahan, T. and Greenstein, S., 1996. Technical progress and co-invention in computing and in the uses of computers. Brookings Papers on Economic Activity, 1-&.

Brown, J. R. and Goolsbee, A., 2002. Does the Internet make markets more competitive? Evidence from the life insurance industry. Journal of Political Economy, 110(3), 481-507.

Brynjolfsson, E., 1996. The contribution of information technology to consumer welfare. Information Systems Research. 7(3), 281-300.

Brynjolfsson, E. and Hitt, L., 1995. Information Technology as a Factor of Production: The Role of Differences Among Firms. Economics of Innovation and New Technology, 3(3-4), 183-201.

BrM

Science, 42(4), 541-558.

Brynjolfsson, E. and Hitt, L. M., 1998. Beyond the productivity paradox. Communications of the Acm, 41(8), 49-55.

Brynjolfsson, E. and Hitt, L. M., 2000. Beyond computation: Information technology, organizational transformation and business performance. Journal of Economic Perspectives, 14(4), 23-48.

Brynjolfsson, E., Hitt, L. M. and Yang, S. K., 2002. Intangible assets: Computers and organizational capital. Brookings Papers on Economic Activity(1), 137-198.

Brynjolfsson, E. and Yang, S. K., 1996, Information Technology and Productivity: A Review of the Literature, Advances in Computers. Academic Press, pp. 179-214.

Caroli, E. and Van Reenen, J., 2001. Skill-biased organizational change? Evidence from a panel of British and French establishments. Quarterly Journal of Economics, 116(4), 1449-1492.

Clay, Karen, Krishnan, R. and Wolff, Eric, 2001, Prices and price dispersion on the web : evidence from the online book industry. National Bureau of Economic Research, Cambridge, MA.

David, P. A., 1990. The Dynamo and the Computer - an Historical-Perspective on the Modern Productivity Paradox. American Economic Review, 80(2), 355-361.

Dewan, S. and Kraemer, K. L., 2000. Information technology and productivity: Evidence from countrylevel data. Management Science, 46(4), 548-562.

Dewan, S. and Min, C. K., 1997. The substitution of information technology for other factors of production: A firm level analysis. Management Science, 43(12), 1660-1675.

DiNardo, J. E. and Pischke, J. S., 1997. The returns to computer use revisited: Have pencils changed the wage structure too? Quarterly Journal of Economics, 112(1), 291-303.

Doms, M., Dunne, T. and Troske, K. R., 1997. Workers, wages, and technology. Quarterly Journal of Economics, 112(1), 253-290.

Dossantos, B. L. and Peffers, K., 1995. Rewards to Investors in Innovative Information Technology Applications - First Movers and Early Followers in Atms. Organization Science, 6(3), 241-259.

Ellison, G. and Ellison, S., 2001. Search, Obfuscation and Price Elasticities on the Internet. Working Paper.

Garicano, L. and Kaplan, S. N., 2001. The effects of business-to-business e-commerce on transaction costs. Journal of Industrial Economics, 49(4), 463-485.

Goldin, C. and Katz, L. F., 1998. The origins of technology-skill complementarity. Quarterly Journal of Economics, 113(3), 693-732.

Goolsbee, A., 2001. Competition in the computer industry: Online versus retail. Journal of Industrial Economics, 49(4), 487-499.

Gordon, R. J., 2000. Does the "new economy" measure up to the great inventions of the past? Journal of Economic Perspectives, 14(4), 49-74.

Greenan, Nathalie and Guellec, Dominique, 1998. Firm Organization, Technology and Performance: An Empirical Study. Economics of Innovation and New Technology, 6(4), 313-349.

Greenan, Nathalie, Mairesse, Jacques and National Bureau of Economic Research, 1999, Organizational change in French manufacturing : what do we learn from firm representatives and from their employees. National Bureau of Economic Research, Cambridge, MA.

Greenstein, S., 1997, From Superminis to Supercomputers: Estimating Surplus in the Computing Market. In: T. Bresnahan and R. J. Gordon (Eds.). The Economics of New Goods. University of Chicago Press, Chicago, pp. 329.

Hammer, M., 1990. Reengineering Work - Dont Automate, Obliterate. Harvard Business Review, 68(4), 104-112.

Hannan, T. H. and Mcdowell, J. M., 1990. The Impact of Technology Adoption on Market-Structure. Review of Economics and Statistics, 72(1), 164-168.

Hitt, L., 1999. Information Technology and Firm Boundaries: Evidence from Panel Data. Information Systems Research, 10(2), 134-149.

Hitt, L. and Frei, F., 2002. Do Better Customers Utilize Electronic Distribution Channels? The Case of PC Banking. Management Science, 48(6), 762-748.

Hubbard, T. N., 2000. The demand for monitoring technologies: The case of trucking. Quarterly Journal of Economics, 115(2), 533-560.

Hubbard, Thomas N. and National Bureau of Economic Research, 2001, Information, decisions, and productivity : on-board computers and capacity utilization in trucking. National Bureau of Economic Research, Cambridge, MA.

Ichniowski, C., Shaw, K. and Prennushi, G., 1997. The effects of human resource management practices on productivity: A study of steel finishing lines. American Economic Review, 87(3), 291-313.

Jorgenson, D. W. and Stiroh, K. J., 1999. Information technology and growth. American Economic Review, 89(2), 109-115.

Jorgenson, Dale and Stiroh, Kevin, 1995. Computers and Growth. Economics of Innovation and New Technology, 3(3-4), 295-317.

Kelley, M. R., 1994. Productivity and Information Technology - the Elusive Connection. Management Science, 40(11), 1406-1425.

Krueger, A. B., 1993. How Computers Have Changed the Wage Structure - Evidence from Microdata, 1984-1989. Quarterly Journal of Economics, 108(1), 33-60.

Kwon, Myung Joong and Stoneman, Paul, 1995. The Impact of Technology Adoption on Firm Productivity. Economics of Innovation and New Technology, 3(3-4), 219-235.

Lehr, W. and Lichtenberg, F. R., 1998. Computer use and productivity growth in US federal government agencies, 1987-92. Journal of Industrial Economics, 46(2), 257-279.

Lev. Baruch and Radakrishnan, Suresh. 2003. The Measurement of Firm-Specific Organization Capital. National Bureau of Economic Research, Cambridge, MA.

Lichtenberg, F. R., 1995. The Output Contributions of Computer Equipment and Personnel: A Firm-Level Analysis. Economics of Innovation and New Technology, 2(3-4), 201-219.

Litan, Robert E. and Rivlin, Alice M., 2001, Beyond the dot.coms : the economic promise of the Internet. Internet Policy Institute : Brookings Institution Press, Washington, D.C.

Litan, Robert E., Rivlin, Alice M. and Brookings Task Force on the Internet, 2001, The economic payoff from the Internet revolution Robert E. Litan, Alice M. Rivlin, editors. Internet Policy Institute/Brookings Institution Press, Washington, D.C.

Lucking-Reiley, D., 2000. Auctions on the Internet: What's being auctioned, and how? Journal of Industrial Economics, 48(3), 227-252.

Lucking-Reiley, D. and Spulber, D. F., 2001. Business-to-business electronic commerce. Journal of Economic Perspectives, 15(1). 55-68.

Macher, J.T. and Mowery, David C., 2004, forthcoming. 'Managing' Learning by Doing: An Empirical Study in Semiconductor Manufacturing. Journal of Product Innovation Management.

Machin, S. and Van Reenen, J., 1998. Technology and changes in skill structure: Evidence from seven OECD countries. Quarterly Journal of Economics, 113(4), 1215-1244.

McKinsey, 2001. US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors, McKinsey Global Institue.

Milgrom, P. and Roberts, J., 1990. The Economics of Modern Manufacturing - Technology, Strategy, and Organization. American Economic Review, 80(3), 511-528.

Mortimer, Julie Holland, 2001. An empirical study of contractual arrangements and inventory : the U.S. video rental industry. Thesis Ph D --UCLA 2001 Thesis.

Mukhopadhyay, T., Kekre, S. and Kalathur, S., 1995. Business Value of Information Technology - a Study of Electronic Data Interchange. Mis Quarterly, 19(2), 137-156.

Mukhopadhyay, T., Rajiv, S. and Srinivasan, K., 1997. Information technology impact on process output and quality. Management Science, 43(12), 1645-1659.

Oliner, S. D. and Sichel, D. E., 1994. Computers and Output Growth Revisited - How Big Is the Puzzle. Brookings Papers on Economic Activity(2), 273-334.

Osterman, P., 1986. The Impact of Computers on the Employment of Clerks and Managers. Industrial & Labor Relations Review. 39(2), 175-186.

Osterman, P., 1991, The Impact of IT on Jobs and Skills. In: M. Scott Morton (Ed.), The Corporation of the 1990s. Oxford University Press, pp. 220-244.

Osterman, P., 1994. How Common Is Workplace Transformation and Who Adopts It. Industrial & Labor Relations Review, 47(2), 173-188.

Quinn, J. B. and Baily, M. N., 1994, Information Technology: the key to service performance, The Brookings Review, pp. 37-41.

Scott Morton, Fiona, Zettelmeyer, Florian and Silva-Risso, Jorge M., 2001, Consumer information and price discrimination : does the Internet affect the pricing of new cars to women and minorities? National Bureau of Economic Research, Cambridge, MA.

Scott Morton, Fiona, Zettelmeyer, Florian, Silva-Risso, Jorge M. and National Bureau of Economic Research, 2000, Internet car retailing. National Bureau of Economic Research. Cambridge, MA.

Shapiro, Carl and Varian, Hal R., 1998, Information rules : a strategic guide to the network economy. Harvard Business School Press. Boston, Mass.

Siegel, Donald, Griliches, Zvi and National Bureau of Economic Research, 1991, Purchased services, outsourcing, computers, and productivity in manufacturing. National Bureau of Economic Research, Cambridge, MA.

Srinivasan, K., Kekre, S. and Mukhopadhyay, T., 1994. Impact of Electronic Data Interchange Technology on Jit Shipments. Management Science, 40(10), 1291-1304.

Stiroh, K. J., 2002. Information technology and the US productivity revival: What do the industry data say? American Economic Review, 92(5), 1559-1576.

.Triplett, J.E., 1996, High-Tech Industry Productivity and Hedonic Price Indices. In: Organization for Economic Cooperation and Development (Ed.), Industy Productivity. OECD, Paris, pp. 119-142.

Varian, Hal R., 2002, Netting A Profit, Optimize.

Wyckoff, A.W., 1995. The Impact of Computer Prices on INternational Comparisons of Labor Productivity. Economics of Innovation and New Technology, 3, 277-293.

Zettelmeyer, Florian, Silva-Risso, Jorge M., Scott Morton, Fiona and National Bureau of Economic Research, 2001, Cowboys or internet car prices lower? National Bureau of Economic Research, Cambridge, MA.